

How does dietary lipid lower blood alcohol concentrations?

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SUMMARY To determine the mechanism, whereby food lowers blood alcohol concentrations, gastric emptying and blood alcohol profiles were measured in six healthy male volunteers after they had drunk a 200 ml solution of vodka and orange juice containing 0.5 g/kg alcohol. Subjects were studied on two separate occasions during infusion of isosmotic solutions of either Intralipid or saline into the ileum *via* an intestinal tube. Gastric emptying was significantly delayed by ileal infusion of fat emulsion and the peak blood alcohol concentration was significantly depressed. Similar effects were observed in three subjects when the solutions were infused into the duodenum. These results suggest that the reduction in alcohol absorption by food does not depend on the physical relationship between the alcohol and the food or between the food and the absorbing epithelium, but is probably caused by a delay in the delivery of alcohol to the small intestine, from where it is rapidly absorbed.

Blood alcohol levels are lower if alcohol is ingested with food than if alcohol is taken alone.^{1 2} Moreover, ingestion of milk or olive oil before a drink of alcohol is said to reduce feelings of inebriation. The mechanism underlying these effects in man has not been established. It is assumed that the effect of nutrients is related to a delay in alcohol absorption, as hepatic metabolism of alcohol appears unaffected by the absorption of food.³ Food may delay alcohol absorption by limiting its access to the epithelial lining of the stomach or the small intestine, either because of dilution or impaired mixing or because fat in some way coats the absorbing epithelium. Some food components may even oxidise alcohol.⁴ Finally, food could reduce blood alcohol concentrations by delaying the delivery of alcohol from the stomach to the small intestine, because alcohol absorption occurs more rapidly from the small intestine of experimental animals than from the stomach,^{5 6} and alcohol absorption is more rapid in patients with partial gastrectomy, who have rapid gastric emptying, than in normal subjects.⁷

We have investigated the effect of infusion of fat emulsion into the small intestine on gastric emptying

and blood alcohol concentrations in normal subjects. The lipid was infused into the ileum to minimise possible interactions between alcohol and food and between food and the absorbing epithelium.

Methods

SUBJECTS

Paired studies were carried out in six healthy men (age 19-23 years) who normally consumed about 2-3 pints of beer per week, but had not taken any drugs or alcohol for a period of a week before the test. Each subject gave written informed consent to a protocol approved by the hospital ethical committee.

PROTOCOL

On the day before the study, each subject swallowed a single lumen radio-opaque polyvinyl tube, equipped with a distal side opening and terminating in a latex bag containing 1.2 ml of elemental mercury. The tube was positioned with the aid of fluoroscopy so that the distal side opening was in the distal small intestine (205 cm from the teeth). The bag plus a small length (1 cm) of tubing was then blown off by rapid injection of 25 ml of air,⁸ preventing the tube from progressing further down the gut. The subject

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was then allowed to eat *ad lib* until 7 pm. He then fasted overnight and the next morning a saline solution (0.9% w/v) or an isosmotic fat emulsion (Intralipid; (20%) Kabivitrum, Ealing, London) was infused into the ileum at a rate of 1.2 ml/min for a period of 88 minutes (equivalent to 106 ml containing approximately 211 Kcal). Twenty minutes after the infusion started the subject drank a 200 ml solution of vodka (Smirnoff) and orange juice containing 0.5 g/kg of ethanol and labelled with 25 μ Ci of 99m Tc-tin colloid. The time taken to drink the solution was always less than five minutes. The subject then lay on a comfortable couch while the radioactivity over the gastric fundus was monitored at five minute intervals using a single crystal scintillation detector linked to a ratemeter. Previous studies have shown that this method provides a profile of gastric emptying which compares favourably with the data from the gamma camera.^{9 10} The time at which the radioactive counts reached half of their value, measured immediately after ingestion of the meal, was recorded as the half time for gastric emptying ($t_{1/2}$). Blood samples for alcohol determination were taken from a catheter situated in a forearm vein before and at 15 minute intervals after drinking the vodka and orange for a total of 180 minutes. To avoid contamination, the skin was cleaned with a non-alcoholic solution of chlorhexidine and cetrimide.

The experiment was repeated on the following day using the other ileal infusion. The order in which the ileal solutions were infused was randomised.

In a separate series of experiments carried out in three volunteers, the effect of infusion of either Intralipid or saline into the duodenum (80 cm from the teeth) on gastric emptying and blood alcohol profiles were determined. The protocol was similar in all other respects with the ileal studies described above.

MEASUREMENT OF BLOOD ALCOHOL

Samples of whole blood were stored at 4°C in Oxalatefluoride vacutainers (Vacutainer Systems, Rutherford, UK), and were assayed within 72 hours of collection by head space analysis on a gas chromatograph,^{11 12} using a chromosorb 101 column (mesh 100/120), operated at a temperature of 100°C, and an internal standard of propan-1-ol (1 mg/ml). The gas flow rates were: hydrogen 40 ml/min; argon 40 ml/min; air 150 ml/min, and the temperature of the detector was 180°C.

STATISTICAL ANALYSIS

The statistical significance of the data was determined using Student's paired *t* test.

Results

INFUSION OF LIPID INTO THE ILEUM

Ileal infusion of lipid significantly delayed gastric emptying and depressed the blood alcohol concentrations. During the saline infusion, the blood alcohol concentrations rose rapidly and peaked within 60 minutes of the drink (Fig. 1) in every subject. Infusion of lipid into the ileum lowered the alcohol profile (Fig. 1) and caused significant reductions in peak alcohol levels (lipid; 24 ± 4 , saline; 37 ± 3 mg per 100 ml, $p < 0.01$, $n = 6$, mean \pm SEM). In one subject, whose gastric emptying was unaffected by lipid, the peak alcohol level also remained unaltered (Table).

INFUSION OF LIPID INTO THE DUODENUM

The effects of lipid infusion into the duodenum were similar to those obtained with ileal infusion; gastric emptying was delayed (Fig. 2) and peak blood

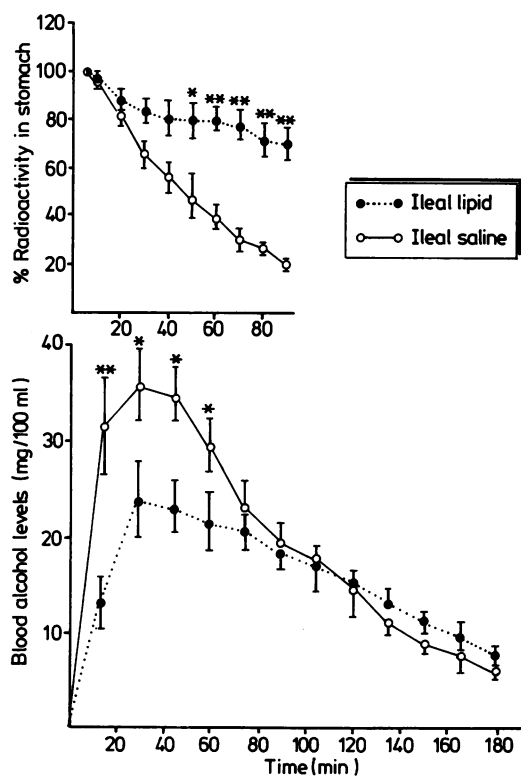


Fig. 1 Mean gastric emptying (top) and blood alcohol profiles (bottom) observed in six subjects, who had ingested the alcohol drink during ileal infusions of Intralipid or saline. The asterisks indicate points of significance. (* $p < 0.05$, ** $p < 0.005$).

Table Individual results for gastric emptying and peak alcohol concentrations in normal subjects undergoing duodenal and/or ileal infusions of Intralipid and saline

Subject	Ileal infusion (n=6)				Duodenal infusion (n=3)			
	Gastric emptying $t_{\frac{1}{2}}$ (min)		Peak alcohol (mg/100 ml)		Gastric emptying $t_{\frac{1}{2}}$ (min)		Peak alcohol (mg/100 ml)	
	Saline	Lipid	Saline	Lipid	Saline	Lipid	Saline	Lipid
1	34	>180	31.0	15.0	45	90	33.0	17.0
2	46	>180	32.0	18.0	24	>180	33.1	12.2
3	41	142	41.0	26.0	31	107	41.0	26.1
4	29	137	39.0	25.0	—	—	—	—
5	59	>180	47.8	31.2	—	—	—	—
6	68	74	37.8	37.8	—	—	—	—

alcohol concentrations were reduced (lipid; 19 ± 4 , saline; 36 ± 3 mg/100 ml, $p < 0.025$, $n = 3$, mean \pm SEM).

Discussion

This study has shown that the presence of lipid in the

distal small intestine lowers blood alcohol profiles. Because alcohol is rapidly absorbed in upper gastrointestinal tract, it is unlikely that the reduction in alcohol concentrations is caused by any physical interaction between the lipid and alcohol or between the lipid and small intestine. Instead the data suggest that the reduction in alcohol profiles by the presence of fat in the small intestine is directly related to a delay in the delivery of alcohol from the stomach into the small intestine. Thus, although alcohol can be absorbed from the stomach and the mouth, the intestine with its large surface area is probably the most important site for alcohol absorption in man as well as experimental animals.^{5,6}

Although it has been known for some time that the presence of lipid in the duodenum and jejunum delays gastric emptying,¹³ the effects of nutrients on the distal small intestine had been little investigated. It is now clear that ileal lipid causes a marked delay in emptying of both solid and liquid meals^{8,14} and reduces blood sugar and insulin profiles.¹⁵ Ileal infusion was used in this study to reduce the possibility of direct interaction between the lipid and the alcohol, though duodenal infusion of lipid had similar effects on gastric emptying and blood alcohol profiles. Thus the data suggest that lipids in food can slow alcohol absorption by acting throughout the small intestine to delay the delivery of alcohol to its absorptive site. The exact mechanism by which lipid achieves this effect is unknown, though the data suggests that endogenous opiates, adrenoreceptors (unpublished data), neurotensin or enteroglucagon are not involved.⁸

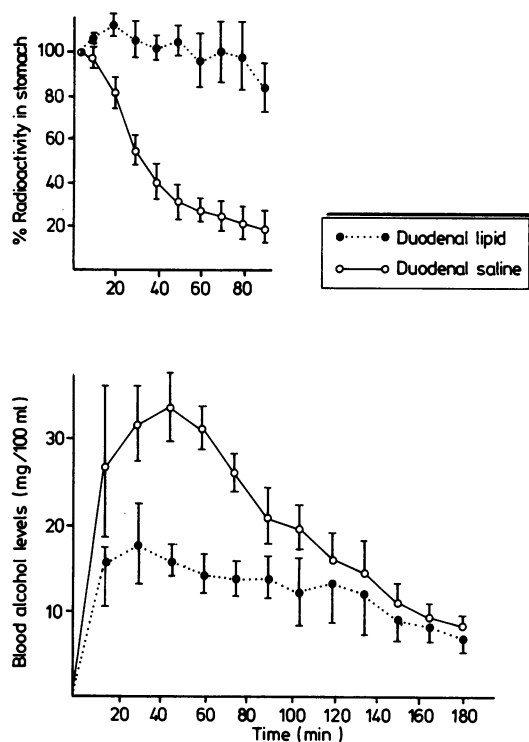


Fig. 2 Mean gastric emptying (top) and blood alcohol profiles (bottom) observed in three subjects, who had ingested the alcohol drink during duodenal infusions of Intralipid or saline.

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